

Spread of the Southern African Lycaenid butterfly, *Cacyreus marshalli* Butler, 1898, (LEP: Lycaenidae) in the Balearic Archipelago (Spain) and considerations on its likely introduction to continental Europe

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Abstract. The establishment of the lycaenid butterfly *Cacyreus marshalli* on the island of Majorca (Spain), originating from southern Africa, has already been reported (Eitschberger & Stamer, 1990; Sarto i Monteys & Masó, 1991). The latter warned of the likelihood of this species being introduced to neighbouring areas, particularly the north-eastern coast of Spain (the Communities of Valencia and Catalonia) and the other islands of the balearic archipelago.

The present work reports the finding of this species on the islands of Menorca and Ibiza and its apparent absence, for now, from the island of Formentera. Its present status in the archipelago is discussed with the likelihood of invading the Iberian Peninsula and the european continent.

Resumen. El establecimiento del licénido *Cacyreus marshalli* en la isla de Mallorca, procedente de Africa meridional, ya había sido constatado en trabajos anteriores (Eitschberger & Stamer, 1990; Sarto i Monteys & Masó, 1991). En éstos se advertía de la posibilidad de que esta especie fuera también introducida en áreas cercanas principalmente en las zonas costeras valencianas y catalanas, y por supuesto, en las restantes islas que conforman el archipiélago balear.

En el presente trabajo se da cuenta del reciente hallazgo de esta especie en las islas de Menorca e Ibiza así como, por el momento, de su ausencia en la de Formentera. Asimismo se hacen algunas consideraciones sobre el estado actual de la especie en el archipiélago balear y se comenta la posibilidad de que invada la Península ibérica y el continente europeo.

INTRODUCTION

The establishment of a breeding population of the african lycaenid, *Cacyreus marshalli* Butler, 1898, on the island of Majorca (Spain) was first confirmed by Sarto i Monteys & Masó (1991), though it had been previously suspected by Raynor (1990) and Eitschberger & Stamer (1990). The latter also made the first correct identification of this introduced species. Data on its biology on Majorca were first reported by Sarto i Monteys & Masó (1991), Masó & Sarto i Monteys (1991) and more recently by Sarto i Monteys (1992). This species may become a serious

pest of cultivated geraniums (*Pelargonium*), should proper control measures not be taken as has already happened in Majorca.

As a result of its recent discovery on the islands of Menorca and Ibiza, comments will be made on its present status in the archipelago as well as on the likelihood of it invading the Iberian Peninsula and the European mainland.

NEW DATA ON DISTRIBUTION

During Easter 1992, two very worn males were caught within a residential area known as 'La Dehesa', north of Castellón de la Plana, in the Autonomous Community of Valencia. This region is by the sea and has abundant ornamental geraniums. The specimens were sent to Dr. Fidel Fernández Rubio, who identified them as *C. marshalli* (Fernández Rubio, pers.comm.). These represent the first record in the wild of this species in the Iberian Peninsula and the second in the European mainland. A male specimen had been found in Brussels (Belgium) on August 3, 1991 (Troukens, 1991).

However, the history of the introduction of this species into Europe goes back to November 1978, when two caterpillars were found in Cheshunt, Hertfordshire (United Kingdom). Those had been accidentally imported on *Pelargonium* plants var. 'Fever Cascade', which had originated from the Republic of South Africa. The larvae were impounded and eventually completed their larval development at the laboratories of the British Ministry of Agriculture, Fisheries and Food (MAFF) in Harpenden, Hertfordshire. Figure 1 shows a map of Western Europe indicating where the species has been found. Figure 2 shows the islands of the Balearic archipelago and the surrounding coasts of the Valenciana and Catalanian communities.

In October 1990 Ulf Eitschberger and Paul Stamer correctly identified the species for the first time from specimens collected by the latter in Paguera (Majorca) in November 1989. They suggested the butterfly or its first instars had been introduced with the foodplants and became established. They were however unaware of the extensive damage the larvae of the butterfly were doing to the geraniums and did not realize the species already had a strong foothold on the island.

Two weeks before the paper by Eitschberger & Stamer was published, Edward M. Raynor (1990) reported photographs of the lycaenid and identified it as "possibly *ethiopicus*" (one of the nine species belonging to the genus *Cacyreus*). And follows Raynor "As far as I'm aware, this genus has not been recorded from Europe or North Africa. Interestingly we observed further specimens in the nearby town of Magalluf, suggesting that the butterfly may be breeding on Majorca. Several members of this genus feed on geranium and pelargonium and they may have been introduced with plants,..". Raynor saw the butterfly for the first time in April 1990 when he was at a friends' garden in Cabo Falcó, south of Magalluf, and a bit later in Magalluf itself.



Cacyreus marshalli Butler, 1898 in Europe (31 August 1993)

- * 1-5 Records of very few specimens. Established breeding population not found
- a-f Established breeding population found.

Figure 1. Map of Western Europe showing where *Cacyreus marshalli* has been found so far (August 1993): 1* Cheshunt, Hertfordshire (United Kingdom) (1978), 2* Brussels (Belgium) (1991), 3* Castellón de la Plana (Spain) (1992), 4* Denia (Alicante-Spain) (April 1993), 5* Granada (Spain) (July 1993). In 1* to 5* only few specimens were found, with an established breeding population not detected. It is established on the islands of the Balearic archipelago (a) Ibiza, (b) Majorca and (c) Menorca. Breeding populations have also been recently found in July 1993 in (d) Logroño, (e) Zaragoza and (f) Valencia.

As to the two specimens collected near Castellón de la Plana, in Spain, it could not be assumed the species had already established itself on the Peninsula. To be certain it would be necessary to find a population of larvae on geraniums and check its permanence over time, as on Majorca. These two specimens, and perhaps others, might have been introduced



Figure 2. Map showing the territories of the Spanish Autonomous Communities of Catalonia, Valencia and Balearic. All major islands of the Balearic archipelago, with the exception of Formentera, are fully invaded by the pest. The square indicates the area where it is suspected *C. marshalli* took the first foothold on the archipelago.

from Majorca (it is known the species is not a migrant), probably as a larva or adult, and they would not have been able to establish a breeding population. The same would apply to the specimen found in Brussels.

Recently, I have been informed by my colleagues at the Plant Protection Service in the Autonomous Community of the Balearic islands that geranium growers settled on the island of Menorca, the second in size of the archipelago after Majorca, had detected this species inside their nurseries. Nearly simultaneously, a paper by the British entomologist P.R.Grey (1992) was published, where he reported the presence of the

species in gardens close to the sea located at Cala de Santa Galdana, on the south west of the island. The butterflies were detected in October 1991 and, on the occasion of a second visit of Grey to Menorca, again in early May 1992. Likewise, according to Grey, another lepidopterologist also found the species in April 1992, in Son Bou, village located on the south centre of the island. Thus, being aware of what happened to the island of Majorca, we can assume also the island of Menorca has been fully invaded by *Cacyreus marshalli*.

However, the Pityusic islands, Ibiza and Formentera, the closest to the Spanish mainland and the southernmost archilepagic islands, had so far not been reported as hosting *C. marshalli* populations. To check whether this species had established on these two islands, I visited Ibiza during December 27, 28 and 30, 1992, and Formentera, on December 29, 1992.

Results were positive on the island of Ibiza. Formentera seems to be, for the time being (December 1992), free of the pest.

On December 27, 1992 I found a large population of this pest in Sant Antoni de Portmany, a town located on the west coast of Ibiza. Geraniums were so infested, specially those in flowerpots near the harbour, that some young plants were completely dead. Older geraniums, within the same area, though alive, were severely damaged, with evident external and less obvious internal stem damage, the latter by galleries produced by boring larva inside the more tender upper stems. I found caterpillars in third and fourth (last) instars. These were found, healthy and active, feeding inside the galleries excavated in the stems. On the outside of the stems they produced the typical 'nibble' injuries (Sarto i Monteys, 1992). When entire stems were too damaged or, in the case of old geraniums, when only the tougher sections of the stems remained undamaged, then a few larvae were found feeding on leaves. I also found very healthy looking pupae and pupa exuviae attached external to the stems. However, I did not observe adults, probably due to the very low (for the area) December temperatures.

On December 30, 1992 the north of the island of Ibiza was explored, with two towns visited: Sant Miquel de Balansat (north centre) and Cala Sant Vicent (north east). The first is located inland, at a few kilometres from the coast and on hilly mountains; the second is by the sea. In both places I found *Cacyreus marshalli*, affecting both *Pelargonium zonale* and *Pelargonium peltatum*. At the first locality I found all larval instars. They were outside or inside terminal shoots which, together with the flower buds, are the preferred feeding sites. At the second locality only live pupae and pupa exuviae were detected, with damage produced on geraniums very obvious.

The temperatures on the island during these late December days were relatively low, with minima between 7 and 11°C. These temperatures seemed well tolerated by *C. marshalli* caterpillars. No photoperiod driven diapause (i.e. due to short daylength) was observed, contrary to what happens in most autochthonous lepidoptera. This had already been

observed by Sarto i Monteys & Masó (1991) in the laboratory during the winter months of December and January using a controlled and fixed temperature of 20°C. Their supposition appears supported that in the wild this species would not present a photoperiod-driven diapause and that low winter temperatures would simply slow down its biological cycle.

On the other hand, it seems the species has not yet reached the isle of Formentera. On December 29, 1992, I visited Formentera to search for this pest. It is the smallest regularly inhabited island of the balearic archipelago, with an area of only 100 km², and is southernmost in the group. A thorough search of geraniums was undertaken in all population centres as well as more isolated residential areas and country houses. In all locations geraniums were in excellent condition and neither the pest itself nor any vestige of its presence was detected. Occasionally, larvae of the noctuid moths *Heliothis armigera* (Hübner, [1808]) and *Chrysodeixis chalcites* (Esper, 1789) were found feeding on geranium leaves and flowers (the latter only on leaves).

Finally, in July 1993, established breeding populations, with large numbers, have been found thriving in continental Spain. These were detected in the cities of Logroño, Zaragoza and Valencia (see Figure 1).

CONSIDERATIONS ABOUT ITS INTRODUCTION INTO THE BALEARIC ARCHIPELAGO

Another point to establish is when the introduction of this species into the islands of the balearic archipelago occurred, as it is not a migrant (Clark & Dickson, 1971; Eitschberger & Stamer, 1990). On Majorca, according to data provided by Mr. Joan Gomila and Mr. Antoni Cardona of the local Plant Protection Service, the first symptoms of geranium damage likely attributable to *C. marshalli*, were detected in 1987, within private gardens in Santa Ponça, town on the southwest of the island. The identity of the pest was unknown at that time. It follows that the most likely introduction occurred one or two years before.

In the case of of Ibiza, serious damage detected in some areas with the pest found in differing and widely separated localities, suggest that the whole island is invaded, indicating its introduction can not be too recent. It could have happened soon after its initial introduction in Majorca. And the same maybe true for the island of Menorca.

Recall that with low population levels damage to geraniums by *C. marshalli* is practically imperceptible. For an untrained person damage is easily mistaken with that produced by other larvae, such as the noctuid moth *Heliothis armigera*. The last species accounts for nearly 100% of all false alarms detected in Catalonia during actions undertaken to prevent the establishment of *C. marshalli* in this Autonomous Community. To a lesser extent the noctuid moth *Mamestra brassicae* (Linnaeus, 1758) is also involved. Both polyphagous species feed upon geranium flower buds and leaves, but do not affect the stems. Geranium leaves are eaten by a

number of polyphagous larvae, which in turn do not normally eat either flower buds or stems. These include the noctuid *Chrysodeixis chalcites* (Esper, 1789) and the tortricid *Cacoecimorpha pronubana* (Hübner, [1799]). All these species, though, are not geranium pests, with the damage produced small and generally undetected, and never killing the geraniums, which soon recover their healthy appearance. With *Cacyreus marshalli*, though, it is another matter.

It is likely that the southwest end of Majorca, which includes the towns of Paguera, Santa Ponça and Magalluf, was the area where the pest was first established, and from where it probably invaded the rest of the island. The data we have support this hypothesis: first symptoms of damage in Santa Ponça, first sightings of adults by Stamer in Paguera and by Raynor in Cabo Falcó and Magalluf.

I have collected and reared to adults around 300 *Cacyreus marshalli* immatures taken directly from the wild on Majorca. The specimens represent all stages from eggs to pupae, collected across different months and years, without producing a single parasitoid. Martin Honey obtained identical results with a smaller sample. This is very unusual result for autochthonous lycaenid species, which in the wild show parasitism rates of 20% to 30%, reaching in some cases 50%, as in *Iolana iolas* (Ochsenheimer, 1816) (López Munguira, pers. comm.)

This evidence indicates that to date no local autochthonous parasitoids of caterpillars have adapted to caterpillars of this alochthonous lepidoptera. Such an adaptation may happen over time. The lack of parasitoids would account for the population explosion of *Cacyreus marshalli*. In fact, this lycaenid has never been reported as a geranium pest in the countries where it is endemic (southern Africa), undoubtedly because there exist autochthonous parasitoids and predators which keep its population levels well below the pest threshold.

In view of the current colonisation of the three main Balearic islands it is no longer possible to establish with certainty which island received the original introduction of *C. marshalli*. However, the fact that the first symptoms were detected in 1987 on the island of Majorca, that the first collected specimens were taken on this island in mid-November 1989, and that three years later, the same story was repeated on Menorca and Ibiza, makes the hypothesis of its initial introduction into the island of Majorca most likely.

The coastlands of the Communities of Valencia and Catalonia, because of their closeness to the Balearic archipelago, are areas presenting the highest risk of pest introduction. However, two towns on the Valenciana coast present an even higher risk because they are regularly connected by ship to the Ibizan harbour of Sant Antoni de Portmany, where *C. marshalli* is very abundant. Denia in the province of Alicante and Gandia in the province of Valencia are both only about 110 km by sea from Ibiza. Given the high risk of introduction of *C. marshalli* into these localities, necessary preventative measures should be taken by competent authorities in the area.

MEASURES TAKEN BY THE DIFFERENT ADMINISTRATIONS

The Community of Catalonia, through its Service of Plant Protection, started an information campaign in July 1992 by producing a poster and an information leaflet about the butterfly. The aims were to prevent the introduction of this pest into Catalonia and, should any focus be detected in Catalonia, to isolate it and impede its spread.

The Community of the Balearic Islands started a series of trials against this pest in June 1992, testing a total of six different insecticides. The results of these trials were positive, all tested chemicals controlled the pest, with no significant differences among them. Treatments will continue during 1993 (J. Gomila, pers.comm.).

In addition the EPPO (European and Mediterranean Plant Protection Organization), to which Spain belongs, showed concern about this pest in Europe and took the first steps to determine whether or not it was appropriate to declare a quarantine status for this species in Europe in May 1992. Its final decision is pending.

COMMENTS ON THE ECONOMIC IMPORTANCE OF GERANIUMS AND POSSIBILITIES OF CONTROL OF THE PEST

In the Spanish national ranking of ornamental plants, geraniums (i.e. all cultivated varieties of the genus *Pelargonium*) are by far the most important in sales volume as well as in employment for production and marketing. Today there are in continental Spain four major geranium growers, who produce 10 million cuttings a year, distributed to about 500 nursery owners across Spain. Altogether this represents a market of over \$30 million a year.

The United States and Germany are presently the two leading countries in the production and commercialization of geraniums, with 23% and 16% respectively of the world production, estimated at 500 million geraniums a year. In the U.S.A. the wholesale value of geraniums in 1990 exceeded \$160 million, representing 17.3% of all U.S. wholesale bedding plant sales (Berninger, 1992).

As cited above, the last surveys in the balearic archipelago showed that practically all geraniums on the islands of Majorca, Menorca and Ibiza are affected by the pest. People owning gardens, especially those of restaurants with gardens important in creating atmosphere, have already started to substitute geraniums with other species of plants, to the detriment of the geranium industry.

Falling sales of the Spanish wholesale growers are already noticeable. According to data provided by 'Cultius Roig', one of the four major growers mentioned above, with headquarters in Catalonia, the number of geranium cuttings despatched to the island of Majorca fell from 78.582 during the 1991-1992 season to 60.471 during that of 1992-1993 (seasons extend from September to March), a 23% decrease. It is not surprising that growers are concerned about spreading of this pest.

Control of *C. marshalli* in geranium nurseries should not be a problem with precautionary insecticide controls carried out regularly.

The control problem is outside the nurseries after the geranium reaches the consumer as a consequence of the biology of the butterfly. This results from the two first larval instars being obligate endophytes while the last two are facultative endophytes (Sarto i Monteys, 1992). Accordingly contact insecticides (most insecticides) will be useful against the non-endophytic phases, but useless against the endophytic phases which are inside the geranium stems and flowers away from insecticide action. Systemic insecticides, i.e. those penetrating inside plant tissues, would be efficient. However, because of their high toxicity, many are not advisable for domestic gardening.

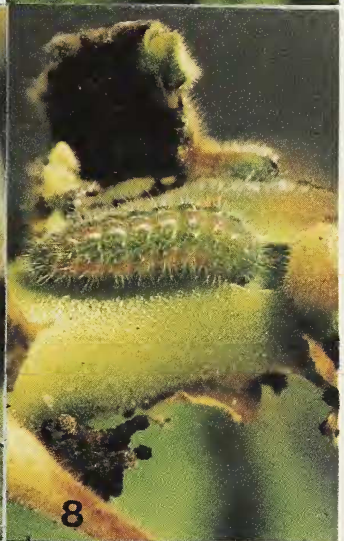
Another worry concerns the possible adaptation of *C. marshalli* to autochthonous species of wild geraniums of the genus *Geranium*, which has already been confirmed with some species in the laboratory (Sarto i Monteys, 1992). The natural foodplant of the butterfly belong to the genera *Geranium* and *Pelargonium* (Clark & Dickson, 1971). If adaptation to wild species occurred, eradication of *C. marshalli* would be practically impossible as there will always exist the risk of reinfestation from wild geraniums.

The most rational alternative would be biological control by its natural parasitoids, to be obtained in the area from which it naturally occurs. Those might accomplish in a short time a much more efficient and cleaner control than that given by chemical insecticides.

In summary, if this pest invaded the Iberian Peninsula or other mediterranean areas from its base on the balearic archipelago, it could

Color Plate 1 (Facing Page)

- Figure
1. *Cacyreus marshalli* adult (upperside)
 2. *Cacyreus marshalli* adult (underside)
 3. Hatched egg on geranium sepal
 4. Endophytic phase: first instar larva and early damage on geranium flower (The cavity has been opened to show larva)
 5. *C. marshalli* pupa
 6. Endophytic phase: second instar larva boring inside a geranium inflorescence peduncle. The gallery has been opened to show larva and its damage. The dark segment above the larva corresponds to its excreta.
 7. Exophytic phase: fourth instar larva feeding from outside on a geranium flower. Notice the larva has its first third inside the young flower, after it pierced the flower sepals to access it.
 8. Exophytic phase: fourth instar larva "nibbling" a geranium stem from outside.
 9. Damage on geranium flowers, pedicels and inflorescence peduncle.
 10. Damage on geranium stem. Stem emptied by *C. marshalli* endophytic activity. The interior gallery has been partially opened to show damage. Notice it is fully filled up with larval excreta.



potentially damage all economic activity committed to the production and commercialization of geraniums. Its partially endophytic habits and its possible adaptation to wild autochthonous geraniums, make the long term consequences difficult to predict.

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